15

Koehler and Wolf Permissible Flame Safety Lamps

U.S. Department of Labor
Mine Safety and Health Administration
National Mine Health and Safety Academy
Revised 1990

Instruction Guide Series

MSHA IG 15

L 38.17/3:

READEX FICHE best copy available

Koehler and Wolf Permissible Flame Safety Lamps

U.S. Department of Labor
Elizabeth Dole
Secretary

Mine Safety and Health Administration
William J. Tattersall
Assistant Secretary

Revised 1990

Instruction Guide Series

MSHA IG 15

PREFACE

This is one of a series of instruction guides developed to help health and safety instructors in the presentation of safety training courses to the people of the mineral industry.

The text is for instructional purposes only and does not constitute an endorsement by the Mine Safety and Health Administration (MSHA) of any specific product.

The guide contains four sections: An introduction to the course stating its objectives and recommended class time; a course outline; the text of the course keyed to visuals developed for use in the course; and questions and answers.

The visuals shown are available as 35-millimeter slides for use with a standard slide projector. Each type of visual developed for the course conveys the same concepts and is keyed to the written material.

For complete information on available training materials and a schedule of current prices, contact:

National Mine Health and Safety Academy
Business Office
P. O. Box 1166
Beckley, West Virginia 25802-1166
(304) 256-3257

CONTENTS

	Page
Introduction	1
Purpose	1
Goals and Methods	1
Objectives	1
Time	2
Student Evaluation	2
Course Outline	3
Permissible Flame Safety Lamps	5
History and Theory	5
Description	6
Care of Flame Safety Lamps	8
Sequence of Disassembly	8
Cleaning, Filling, and Inspecting	10
Sequence of Assembly	11
Preliminary Test	16
Possible Errors in Assembly	16
Using the Flame Safety Lamp	17
Preliminary Checks	17
Lighting and Flame Adjustment	18
Detecting Oxygen-Deficient Atmospheres	18
Testing for Methane	20
Traveling Flame Method	21
"Cap" Flame Method	22
Limitations of the Flame Safety Lamp	23
Glossary	24
Questions and Answers	25

INTRODUCTION

Purpose

The purpose of this course is to instruct underground mining personnel on the proper care and use of the flame safety lamp.

Goals and Methods

The goals of this course are to aid the miners in developing --

1. A basic knowledge of Title 30 of the Code of Federal Regulations regarding oxygen deficiency.
2. The ability to determine oxygen deficiency using the flame safety lamp.
3. A working knowledge of the instrument.

Training methods include lecture/discussion and demonstration techniques reinforced with the use of visual materials. Class participation is encouraged to promote student motivation and the development of concepts.

Objective

The objective of the course will enable the miners to --

1. Understand the basic operating principles of the flame safety lamp by being able to identify the various parts of the lamp and describe their functions.
2. Disassemble, clean, repair, and reassemble the lamp properly.
3. Examine the lamp for permissibility prior to use.
4. Prepare the lamp for use in the mine.
5. Determine an oxygen-deficient atmosphere by using the lamp.
6. Detect and measure methane, with a reasonable degree of accuracy, using the flame safety lamp.
7. Identify the limitations of the lamp.

Time

The time required to complete the Koehler and Wolf Permissible Flame Safety Lamps course is in each mine's approved training plan.

Student Evaluation

A series of suggested questions to be used at the conclusion of the course is included. These questions will help evaluate the effectiveness of the course presentation and materials.

Each participant should demonstrate his/her ability to use the instrument properly.

COURSE OUTLINE

I. Introduction

II. Glossary

III. History and theory

IV. Description

- A. Font assembly
- B. Globe assembly
- C. Bonnet assembly

V. Care of flame safety lamps

- A. Sequence of disassembly
  1. Cleaning
  2. Filling
  3. Inspecting
- B. Sequence of assembly
  1. Preliminary test
  2. Possible errors in assembly

VI. Using the flame safety lamp

- A. Preliminary check
- B. Lighting and flame adjustment
- C. Detecting oxygen-deficient atmosphere
- D. Testing for methane
  1. Traveling flame method
  2. "Cap" flame method

VII. Limitations of the flame safety lamp

VIII. Questions and answers

PERMISSIBLE FLAME SAFETY LAMPS

History and Theory

VISUAL 1

The flame safety lamp operates on a principle credited to Sir Humphrey Davy more than a century ago. Davy found that when metal gauze was placed over a flame, the flame would not pass through the gauze. The gauze safely confined the flame by rapidly dissipating the heat, thus reducing the temperature of the flame below ignition level (Visual 1).

NOTE: Demonstrate the principle. It is this feature which puts the safety into the flame safety lamp.

Davy's lamp was designed primarily for its safe light; however, it soon became the standard device for detecting the presence of methane and the most practical means of detecting the deficiency of oxygen in mine atmospheres. When the lamp is intact, properly cleaned, and assembled, the gauzes give the only direct openings to air outside. They permit enough air movement through the interior of the lamp to provide a sufficient amount of oxygen for the flame to burn, yet prevent the passage of flame from the lamp to the external atmosphere surrounding it. This occurs even though the gas-air mixture explodes within the lamp.

VISUAL 2

The U.S. Bureau of Mines has tested flame safety lamps under adverse conditions that may exist in the mines. The Bureau of Mines has designated two types of lamps as permissible -- the Koehler (Visual 2) and the Wolf. These lamps are safe to use under all conditions, provided they are properly assembled with permissible parts and used by a qualified person. These lamps are the only permissible lamps known to be in use in the United States. The Wolf lamp is still in use but is no longer manufactured.

Description

VISUAL 3

The parts of the Koehler flame safety lamp, the most common type, can be divided into three major groups (Visual 3):

1. The font assembly or base of the lamp contains --
   a. The fuel storage area for a 12-hour supply of fuel.
   b. The igniter assembly, which is used in lighting the lamp.
   c. The wick assembly and wick, which are used to draw a steady supply of fuel from the reservoir for combustion.
   d. The wick adjustment knob, which adjusts the height of the flame.
   e. The lower gauze ring, which allows air to enter the lamp and confines the flame to within the lamp.
2. The globe assembly contains --
   a. Asbestos gaskets, one above and one below the globe, to provide adequate tight joints at each end of the globe.
   b. The globe, an approved glass for observing the flame.
   c. The gasket or globe ring, which retains the upper asbestos gasket.
3. The bonnet assembly contains --
   a. The hood and bonnet for protection of the upper gauzes from mechanical injury and protection from high velocity air current entering the lamp.
   b. The outer gauze, which safely confines the flame by its rapid cooling effect, preventing propagation of the flame from within the lamp to a gassy atmosphere surrounding it.

c. The inner gauze, which serves the same purpose as the outer gauze. The use of two gauzes ensures a much greater safety factor.

d. The expansion ring, which permits expansion of the globe when heated without creating excessive end pressure.

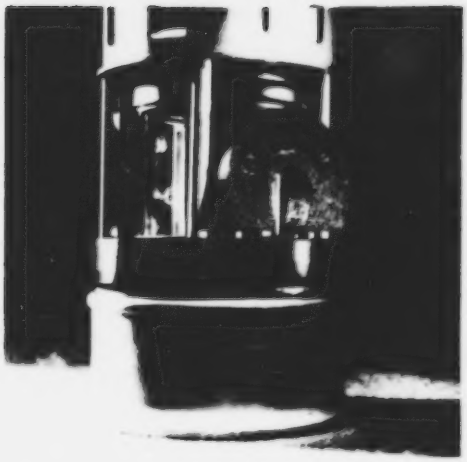
e. The baffle ring, which protects the lower gauze and ensures a more stable flame by preventing direct access of air through the lower gauze.

f. A magnetic lock that prevents opening the lamp underground.

g. Standards to protect the globe against breakage from external blows.

CARE OF FLAME SAFETY LAMPS

VISUAL 4



VISUAL 5

Sequence of Disassembly

Disassembly of the flame safety lamp should be in the following order:

1. Place a magnet on the two lock pins of the magnetic locking device and unscrew the bonnet from the font (Visuals 4 and 5).

   a. Turn the bonnet in a clockwise direction until a click is heard. The click indicates that the lock is free and the magnetic lock open.

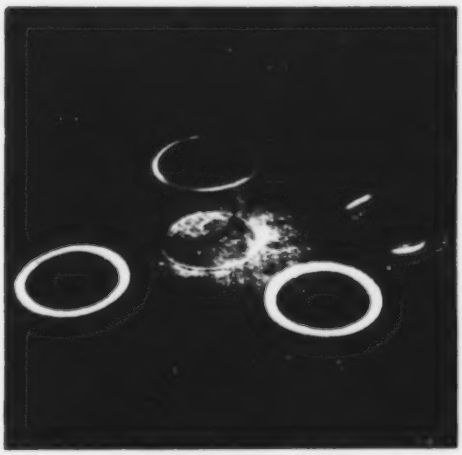
VISUAL 6

b. Unscrew the bonnet in a counter-clockwise direction, continuing to hold the magnet on the two lock pins, until the bonnet and font are separated (Visual 6).

c. The expansion ring will remain between the standards.

VISUAL 7

2. Remove the outer and inner gauzes (Visual 7).



VISUAL 8

3. Remove the gasket ring, globe, and lower gauze ring and gaskets (Visual 8).

The lamp is now broken down into its basic components and is ready for cleaning, filling, and inspection.

Cleaning, Filling, and Inspecting

When all removable parts of the lamp assemblies are detached:

1. Remove all deposits from the igniter file wheel. Test and adjust the igniter to provide adequate sparking.
2. Inspect the wick raising device and clean charred material from the wick.
3. Remove the filler plug and fill the font with a suitable fuel at the designated filling station located in the lamp house. Fill the font sufficiently to completely saturate the cotton packing and wick. The fluid should not be allowed to run over. Pour the excess fluid from the font after each filling. Replace the filling plug, tighten adequately, and properly seat it against the filling-plug gasket.

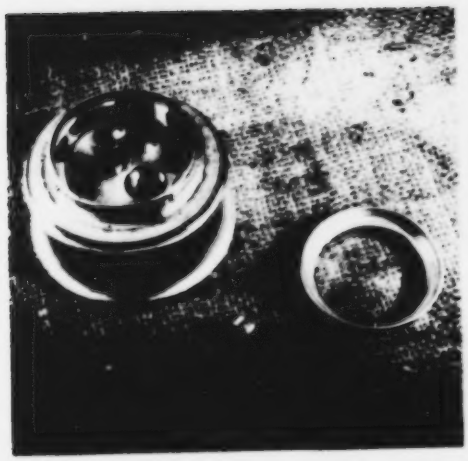
   NOTE: The use of suitable fuels is most important. Because of excessive gumming, motor gasoline is not suitable as a flame safety lamp fuel. Suitable fuels are uncolored, straight-run gasolines, having a medium distillation range of 90° to 300° F.
4. To clean the inner, outer, and lower gauzes, brush with a soft, brass, bristle brush or blow with low compressed air. The gauzes should have the coating burned off before being used. Use iron or brass screen gauzes having a mesh of 28 or 30 (784 or 900 holes per square inch).
5. Clean the globe (lamp glass) thoroughly. Examine the globe for defects, especially cracks and chipped edges.
6. Carefully inspect the asbestos gaskets for possible defects and breaks. Replace defective or doubtful gaskets since they will not form an airtight joint above and below the globe.
7. Clean the soot and dust off bonnet assembly and carefully examine for defects. Deformation of the bonnet usually interferes with normal ventilation and burning of the lamp, and may seriously lower its safety factor.

Sequence of Assembly

To properly assemble the lamp, the following procedure is recommended:

1. Begin with the font assembly which has been properly filled with a suitable fuel, thoroughly cleaned, and thoroughly examined for permissibility and for proper working condition (Visuals 9 and 10).

2. If a Wolf lamp is being assembled properly position the baffle ring on the font.



VISUAL 9

VISUAL 10

VISUAL 11

3. Insert an asbestos gasket in the lower gauze ring and properly set it in place on the font (Visual 11).

VISUAL 12

4. Place the globe (lamp glass) in its proper position (Visual 12).

   a. Koehler lamp -- The inscription, "Pyrex, made in the U.S.A.," should be in the reading position.

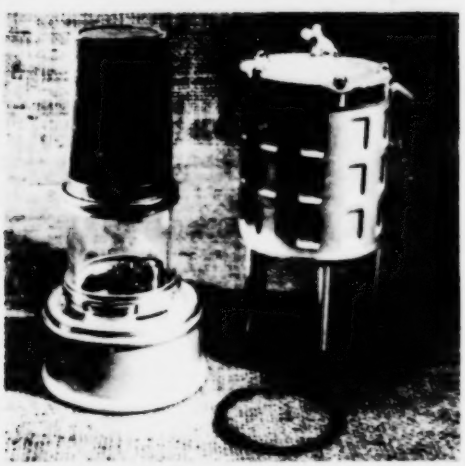
   b. Wolf lamp -- The inscription must be placed upright (in a reading position) to ensure proper positioning of the etched line graduations.

VISUAL 13

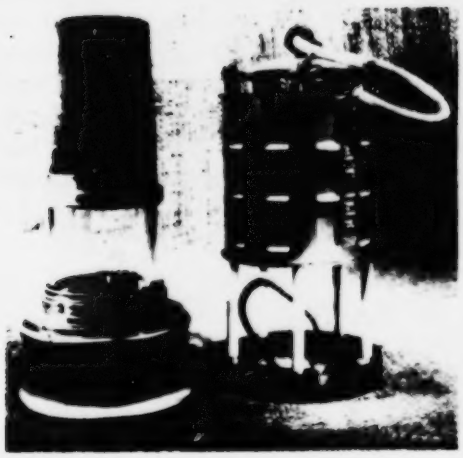
5. Insert an asbestos gasket in the gasket ring (globe ring) and place it over the globe, if assembling a Koehler lamp (Visual 13). When assembling the Wolf lamp, first assemble the inner gauze, the outer gauze, and gauze ring. Then insert an asbestos gasket in the gauze ring.

VISUAL 14

6. Place the inner and outer gauze over the globe (Visuals 14-15).

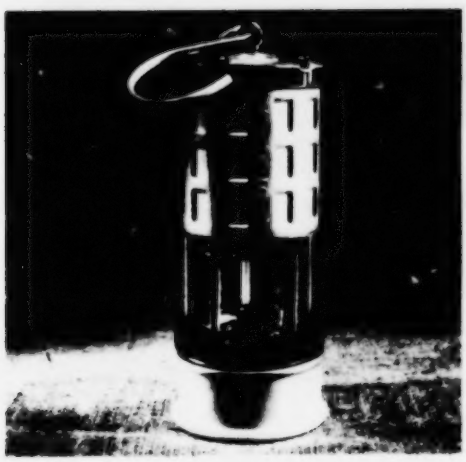


VISUAL 15



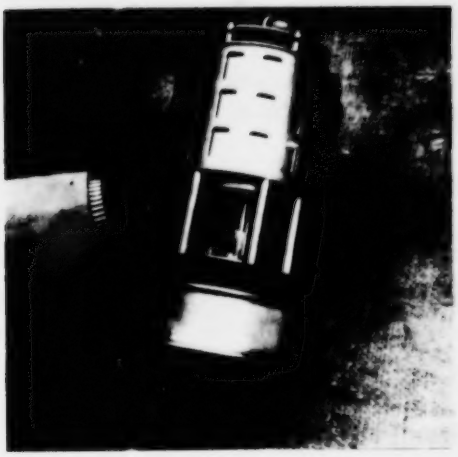
VISUAL 16

7. Insert the expansion ring between the standards of the bonnet assembly (Visual 16).



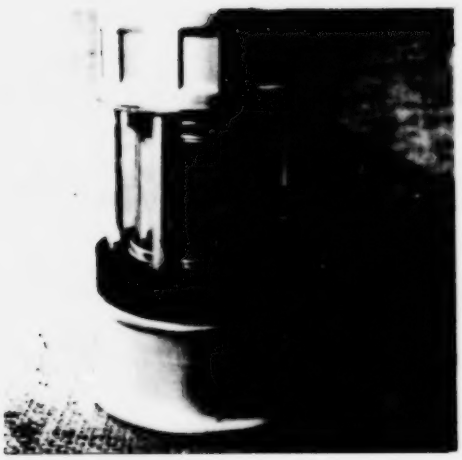
VISUAL 17

8. Place bonnet assembly, with expansion ring in place, over the gauzes (Visual 17).



VISUAL 18

9. Screw bonnet assembly to font threads in a clockwise direction until tight; make sure that the magnetic lock operates and that the lamp is locked. To test for proper tightness, grasp the globe with the thumb and first two fingers and turn. The globe should turn with resistance for correct tightness. Turning easily or not at all is incorrect (Visuals 18-19).



VISUAL 19

Preliminary Test

After the safety lamp is assembled and before it is taken underground, test it in a lamp-testing box containing an explosive mixture of gas and air.

1. Place the unlighted lamp in the box.
2. Operate the lamp's igniter to fire the mixture which has entered the lamp.
3. If the lamp is defective or improperly assembled, the explosion inside the lamp will ignite the gas-air mixture surrounding the lamp causing the rupture of a paper diaphragm at the top of the box.

Possible Errors in Assembly

Some errors likely to occur in assembling the lamp are:

1. Omitting one or both gaskets or using broken gaskets.
2. Omitting one of the gauzes.
3. Failing to adequately tighten the fuel filler plug.
4. Failing to insert expansion ring.
5. Failing to adequately tighten the bonnet to the font to make a tight fit between the globe glass and the gaskets.
6. Tightening the fuel font too much, compressing the expansion ring and destroying its usefulness.
7. Omitting the baffle ring (when assembling the Wolf lamp) which prevents air from blowing directly into the lamp through the lower gauze.
8. Using a distorted shield or bonnet.
9. Placing a defective gauze in a lamp.
10. Not examining each part to see that it is clean and in good condition.

USING THE FLAME SAFETY LAMP

Preliminary Checks

In most cases flame safety lamps will be maintained by a competent and qualified lamp person who is assigned to that job. However, there is a procedure which the person qualified to use the lamp should follow prior to taking the lamp into the mine:

1. Check to see if the lamp is locked.
2. Visually inspect the lamp for dents and dirt.
3. Check to see if the outer gauze is in place by looking down between the hood and the top of the deflector.
4. Check to see if the inner gauze is in place by looking up through the globe.
5. Check the upper asbestos gasket on the globe and ensure that it is in the ring, properly seated, and not defective.
6. Check the globe for cracks, chips, and proper seating.
7. Check the lower gauze ring to see that it is in place and that the asbestos gasket is in proper position and not defective.
8. Check the filler plug to ensure that it is properly tightened below the surface of the font.
9. Check the tightness of the globe. You should be able to turn the globe with resistance, using your thumb and two fingers.
10. Check the wick and the wick feed adjustment by turning the wire adjustment knob on the bottom of the font.
11. Check the igniter for proper operation and snap lock it in the down position.

Lighting and Flame Adjustment

VISUAL 20

Once the lamp has been determined to be permissible, it should be lit and the flame adjusted in an atmosphere free of methane (Visual 20).

1. Extend the wick.
2. Elevate the igniting device.
3. Rotate the igniter until a spark is produced.
4. Adjust the wick for the desired height of flame.

Detecting Oxygen-Deficient Atmospheres

The use of the flame safety lamp for methane detection has been reduced. The lamp's primary function has been to detect oxygen-deficient atmospheres. It must be remembered, however, that the lamp is used only as a supplement to an approved methane detecting device.

When air enters a mine, reactions and oxidation processes take place which cause a decrease in the oxygen and an increase in the carbon dioxide and nitrogen contents. The completeness of these reactions depends upon many factors; the most important ones being: (1) Extent of the mine workings traversed and velocity of the ventilating air; (2) chemical and physical composition of the mineral being mined, especially with reference to its capacity for absorbing oxygen; (3) quantity of timber exposed; (4) number of people in the mine; and (5) temperature and humidity of the mine atmosphere.

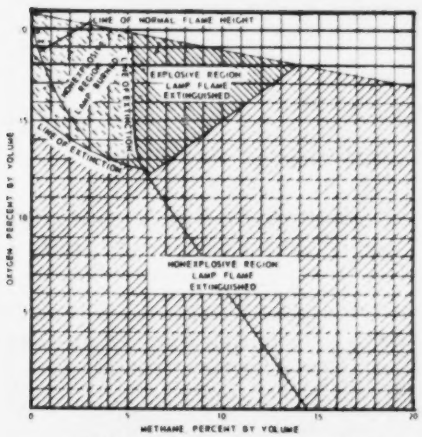
The oxygen content decreases at a higher rate in sections where the air is still or moving very slowly, as at poorly ventilated areas or in old workings. It may be reduced where ventilation is poor and reduced even more in old workings and at sumps.

In the process of oxygen absorption by the mineral, part of the oxygen could be retained on the mineral surfaces and in the pores, part is combined chemically with the mineral constituents and forms complex oxygenated compounds, and part combines with the mineral to form water vapor and carbon dioxide. This loss of oxygen from mine atmospheres leaves an excess of nitrogen which, with the carbon dioxide produced in the oxidation process, is termed "blackdamp."

Any decrease in the oxygen content of mine atmospheres is undesirable from the standpoint of the workers' health and ability to work. At moderate temperatures workers are not likely to be conscious of the deficiency until the oxygen has been reduced to about 13 percent. The effect in most instances is not fatal until the level is less than 10 percent. However, any deficiency should be detected before the 13 percent concentration has been reached.

Oxygen deficiency can be detected readily by its effect upon the flame of a safety lamp. When a lighted lamp is taken into an atmosphere that is deficient in oxygen, the flame momentarily rises in its search for oxygen, then drops to a lower level and changes color. Its height and color depend upon the degree of deficiency and whether methane is present.

Oxygen is necessary for the support of life. People breathe most easily and work best when the air contains about 21 percent oxygen, which is the amount usually present in normal atmospheres. People can live and work, though not as well, where there is less oxygen. People breathing air that has 15 percent oxygen usually become dizzy, notice a buzzing in the ears, have a rapid heartbeat, and often suffer from headache. When the air contains only about 7 percent oxygen, life is greatly endangered.



GRAPH OF FLAME ACTION

VISUAL 21

The flame safety lamp will not burn in a methane-free atmosphere having an oxygen content below 16.25 percent. However, it will burn in atmospheres of lower oxygen content if methane is present (Visual 21). Tests using a safety lamp flame 7/8 inch high show that when methane is present in a mine atmosphere which is deficient in oxygen, the flame height alone is not a reliable indicator of either the percentage of methane content or oxygen deficiency. However, observations of both the height and color of the flame show reliably the presence of more than 1.5 percent methane or less than 16 percent oxygen or combinations of these conditions.

The lamp flame will extinguish when the oxygen content falls below 13 percent, regardless of the percentage of methane present. No one should try to enter or remain in an atmosphere in which a flame safety lamp will not burn unless he/she wears a self-contained breathing apparatus.

NOTE: Demonstrate the proper method of testing for oxygen deficiency.

In a methane-free atmosphere, reduction of the oxygen content of the mine air below the normal 20.95 percent (19.5 percent is the lowest percentage permitted by law) affects both the temperature and the illuminating power of the flame.

Evidence of oxygen deficiency below 16.25 percent in a methane-free atmosphere is an initial increase in flame height in its search for oxygen, followed by a decrease, and then the flame immediately extinguishes.

Testing for Methane

NOTE: Demonstrate the proper method of testing for methane.

TESTING FOR METHANE

1. **HOLD FIRMLY IN UPRIGHT POSITION**
2. **DETERMINE TEST AREA**
3. **RAISE LAMP SLOWLY**
4. **OBSERVE ACTION OF FLAME**
5. **WITHDRAW LAMP SLOWLY**

VISUAL 22

Properly handling the lamp in the process of testing for methane is important and should be done as follows (Visual 22):

1. Hold the lamp firmly, in either hand, by the fuel font in an upright position.
2. Since methane is lighter than air it will be found in the higher locations of the mine or working places.
3. Raise the lamp slowly. It is unwise to thrust a lighted safety lamp in a mine atmosphere known to be potentially explosive. By raising the lamp slowly, the atmosphere can be thoroughly explored.

4. When the behavior of the flame indicates that gas is present, withdraw the lamp slowly. Hasty withdrawal will tend to drive the flame through the gauzes.

5. In the event that a safety lamp is thrust unintentionally into an explosive mixture, which may be indicated by the lamp filling with flame or the wick flame going out, slowly withdraw the lamp and take it to fresh air for relighting.

6. There are two ways to detect methane by observing the length of the safety lamp flame.

   - Observe the draw or change in the height of the traveling flame with the aid of the lined globe.

   - Lower the wick until the flame is nonluminous and then observe the gas cap.

Traveling Flame Method

NOTE: Point out and describe purpose of etched gradation rings on globe.

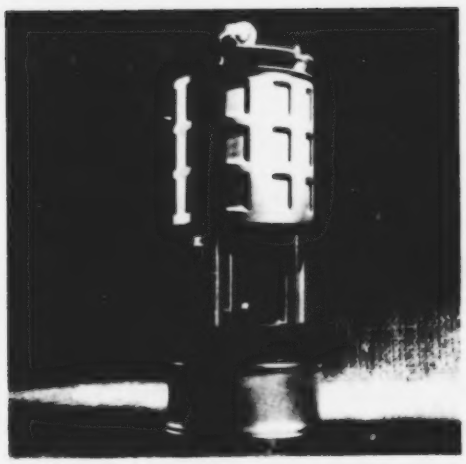
1. First, adjust the height of the flame in fresh air to establish a base height (Visual 23). The highest practical heights are as follows: One inch, or to the middle ring of the globe for the Koehler lamps; and 7/8 inch for the Wolf lamps.

VISUAL 23

2. When in the area to be tested, carefully handle the lamp as previously prescribed. Raise it slowly, continuously observing the yellow luminous flame. By knowing the base height of the flame you will readily see the rise in the flame height when methane is present.

   a. Accurate measurements come only with experience, but when using this method, approximate that for every 1/32 to 1/16 of an inch rise of the flame, 0.5 percent volume of methane is present.

"Cap" Flame Method



VISUAL 24

The "cap" flame method (Visual 24) is more accurate and more positive as an indicator. It will show the presence of gas when there is no opportunity to establish the normal setting of the 1-inch high flame in known fresh air.

1. Lower the wick until only a small blue cap flame remains at its top.

2. Test for methane in the same manner as with the traveling flame method by slowly raising the lamp into the testing zone while constantly observing the cap flame. Complete darkness is required for this method since the pale blue flame is quite difficult to see. The rise of the gas cap is the measure of methane content in the air. Skill in accurately measuring the methane content is obtained only through experience and practice. Concentrations as low as 0.5 percent per volume are readable when using the cap flame method.

LIMITATIONS OF THE FLAME SAFETY LAMP

The flame safety lamp has been a very reliable piece of equipment for more than a century. It has made possible the development and operation of mines that otherwise never could have been worked and has contributed much to miners' safety. However, the lamp does have definite limitations:

1. It is doubtful whether the average observer can measure less than one percent of methane with the ordinary lamp.

2. When enough methane is present, the percentage of gas may be roughly estimated by the height of the "cap," but these estimates are likely to differ considerably from the true value.

3. People charged with the responsibility of detecting methane should be thoroughly experienced and competent in the use and care of the lamps. These people should be checked for good eyesight and color perception.

4. No device can replace the practice of safety and caution which must be a part of the miner's everyday life.

GLOSSARY

1. **Bonnet** - The metal casing with openings for ventilation. The bonnet protects the gauzes from damage and from the impact of high-velocity air.

2. **Cap** - The blue halo of ignited methane which shows above the cap flame of a safety lamp when in air containing small quantities of methane. Also called gas cap.

3. **Cap flame** - A pale blue spot of flame on the top of the wick of a safety lamp. The cap flame is adjusted by lowering the wick and is used for the detection and measurement of methane gas.

4. **Expansion ring** - The metal ring designed to allow for expansion of the globe which is caused by heat from the flame.

5. **Font assembly** - The base of the flame safety lamp that contains the fuel storage area, the igniter assembly, the wick assembly, flame adjustment, and the lower gauze rings.

6. **Gasket** - A flat asbestos washer used for making airtight joints above and below the globe.

7. **Gauze** - The wire mesh used to prevent the passage of flame from the lamp to the external atmosphere.

8. **Globe assembly** - The portion of the lamp that contains the asbestos gaskets, the globe, and the gasket ring.

9. **Lamp house** - A place above ground where the safety lamps are repaired, cleaned, examined, lighted, locked, and tested before being used by the workers.

10. **Methane (CH_4)** - The most common explosive gas found in coal mines. It is a tasteless, odorless, colorless, and nontoxic gas.

11. **Mine atmosphere** - The air in underground workings.

12. **Oxygen deficiency** - When the oxygen content of the mine air is reduced below the allowable limit of the law (19.5 volume percent).

13. **Traveling flame** - A luminous yellow flame used to detect and measure methane.

14. **Wick** - A thin bundle of threads designed to absorb fuel to be burned with a small steady flame.

QUESTIONS AND ANSWERS

NOTE: The questions can be used to reinforce important ideas and to help determine if the instructor was effective in the presentation of materials. All or part of the suggested questions can be used at the instructor's discretion.

1. What are the two permissible flame safety lamps used in the United States?

   The Koehler and the Wolf.

2. How many parts compose the Koehler flame safety lamp?

   Three major visible groups made of ten basic parts.

3. What are the major groups that form the Koehler lamp?

   The font or base, the globe assembly, and the bonnet assembly.

4. What parts form the font?

   The fuel storage area, the igniter assembly, the wick assembly and the wick, the wick adjustment knob, and the lower gauze rings.

5. What parts form the globe assembly?

   The asbestos gaskets, the globe, and the gasket or globe ring.

6. What parts form the bonnet assembly?

   The hood and bonnet, the outer gauze, the inner gauze, the standards, and the locking device.

7. Is the flame safety lamp really "safe," as the name implies?

   The name "safety lamp" can be misleading. The lamp is only made safe by an experienced person with good judgment and good eyesight.

8. How is a flame safety lamp made safe?

   By seeing that:
   a. The various parts are clean.
   b. The parts are in permissible condition.
   c. The parts are properly assembled.
   d. The lamp is magnetically locked before it is taken into the mine.,

9. What is a magnetically locked type safety lamp?

   It is a lamp so constructed that it can be unlocked and disassembled only with a magnet located in the lamp house.

10. What does the cleaning of the lamp involve?

    The cleaning of the lamp involves the removal of all dirt, rust, and inflammable materials from all parts of the lamp.

11. Why must the gauzes be kept in good condition?

    Because they rapidly cool the lamp flame to below the ignition temperature of the surrounding air.

12. How tight must the globe be to ensure a safe joint?

    Until the glass or globe can be turned with difficulty by a thumb and two fingers.

13. How is the safety lamp tested before being taken underground?

    The unlighted lamp is placed into a flame safety lamp testing box containing an explosive mixture of methane and air. The igniter is then operated to ignite the mixture inside the lamp. If the lamp is defective or improperly assembled, an explosion inside the lamp will ignite the gas-air mixture surrounding the lamp causing an explosion that ruptures a paper diaphragm at the top of the box.

14. How does the lamp react to decreased oxygen content in methane-free mine air?

    The flame grows dim as the oxygen content in the mine air decreases, and the flame is extinguished when oxygen content gets as low as 16.25 percent.

15. How is the percentage of methane estimated?

    The length of the flame is used to estimate the percentage of methane gas present in the surrounding air.

16. What is the cap?

    It is the length of the flame or the pale blue flame that appears to ride on the lamp flame.

17. What are the two methods employed for detecting gas with an ordinary flame safety lamp?

    a. Use of a short or capping flame.
    b. Use of a traveling flame about 1 inch high.

18. How will the reduction of the oxygen content of the mine air affect the efficiency of gas detection with a flame safety lamp?

    The lower oxygen concentration affects both the temperature and the illuminating power of the flame. The flame height is not a reliable indicator of the percentage of methane in an oxygen deficient atmosphere. However, the height and color of the flame show reliably the presence of more than 1 1/2 percent methane or less than 16 percent oxygen, or a combination of these conditions, and thus give an adequate safety factor in the detection of either hazard.

19. How will the flame react to oxygen deficiency?

    There is an initial increase in flame height followed by a decrease, unless methane is present. A sustained increase in flame height and a dimming flame shows both the presence of methane and a deficiency of oxygen.

20. Is the flame safety lamp being replaced as a primary methane detecting device?

    The permissible flame safety lamp has been and may be used as a supplementary testing device.

NOTES

NOTES